Hybridization between *Juniperus grandis, J. occidentalis* and *J. osteosperma* in northwest Nevada I: Terpenes, Leviathan Mine, Nevada

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ABSTRACT

The volatile leaf oils of *J. grandis, J. occidentalis, J. osteosperma* and putative hybrids from near Leviathan Mine, NV were analyzed. No evidence of hybridization involving *J. occidentalis* was found. There appears to be hybridization between *J. grandis* and *J. osteosperma*. Only one tree, morphologically typical of *J. grandis*, was found in the Leviathan mine population. One shrub appeared to be, morphologically, pure *J. osteosperma*. PCO, using 49 terpenes, with character matches weighted by F (from ANOVA between parental species) produced no evidence that *J. occidentalis* was involved in hybridization with *J. osteosperma* in this population. PCO analysis (with 42 terpenes), revealed hybrids between *J. grandis* and *J. osteosperma*, and possible backcrosses to *J. osteosperma*. Analyses of 32 of the largest terpene components revealed 6 intermediates, 8 dominant/ recessives; 18 terpenes were transgressive, beyond the range of *J. grandis* or *J. osteosperma*. These transgressive components were truncated to values in the range of the putative parental species and a new PCO indicated the plants to be more intermediate. The terpene analysis seems in agreement with the haplotype data of Terry (2010). Published on-line: www.phytologia.org *Phytologia 95(1): 58-69 (Feb. 1, 2013)*.

KEY WORDS: *J. osteosperma, J. grandis, J. occidentalis*, hybridization, Cupressaceae, terpenes, Leviathan mine, Nevada.

Hybridization among species of Juniperus in north-western Nevada was first reported by Vasek (1966) and confirmed by Terry et al. (2000) and Terry (2010). Terry et al. (2000) found cpDNA (trnL-trnF, trnS-trnG) haplotypes of J. occidentalis in Nevada populations of J. osteosperma, with lower frequencies occurring in Utah, Colorado, and Wyoming. Subsequently, Terry (2010) analyzed trnL-trnF and trnS-trnG (cpDNA) haplotypes and reported similar results (Fig. 1). Notice, all 15 trees of J. occidentalis in Oregon have the same haplotype and that this haplotype is also present in northwest Nevada. The Leviathan mine population was one of the



most diverse populations and contained 5 haplotypes (Fig. 1).

Recently, Adams (2012a) analyzed geographic variation in the leaf essential oils of *J. osteosperma* (Torr.) Little and reported differences among the populations. However, the putative hybrid populations of northwest Nevada were not included in that study.

Figure 1. Distribution of haplotypes (trnL-trnF and trnS-trnG) in *J. occidentalis* and *J. osteosperma* (based on Terry, 2010).

These three western junipers occupy generally allopatric ranges (Fig. 2), with *J. grandis* favoring granitic outcrops in the high Sierra, *J. occidentalis* growing on lava beds at lower elevations in northern California and Oregon, and *J. osteosperma*, preferring the intermediate elevations in the Basin and Range region of Nevada, Utah and adjacent states; a fourth species, *J. californica*, grows in the Mojave desert foothills of southern California, thence northward in the central valley foothills (Adams 2011). Adams (2012b) found that *Juniperus grandis* and *J. occidentals* appear to hybridize in the Beckwourth, CA area (Fig. 2) but, otherwise no evidence of gene flow between these species was found.

The Leviathan mine population, sampled by Terry (2010, popn. 16) appears to be an area of sympatry between *J. grandis* and *J. osteosperma* and subject to ancestral as well as possible current hybridization. Analysis of plants from the Leviathan mine population is the focus of this paper.

MATERIALS AND METHODS

Plant material: *J. grandis*, *Adams 11963-11967*, Jct. US 50 & CA 89, 38° 51.086' N, 120° 01.244' W, 1937 m, Meyers, El Dorado Co.; CA; *Adams 11968-11972*, 16 km w of Sonora Jct., on CA. 108, 38° 18.289' N, 111° 35.598' W, 2585 m, Tuolumne Co.; CA, *J. osteosperma*, *Adams 1689-1699*, *1701-1705*, on US 6, Thistle, 40° 00' 6.9" N, 111° 29' 4.6" W, 1650 m, Utah Co., UT, *Adams 12067-12071*, 4 km n of Sedona, AZ, at Grasshopper Point, on Alt US 89, 34.888° N, 111.733° W, 1380m, Coconino Co., AZ, *Adams 10272-10276*, on NV157, Charleston Mtns., 36° 16.246' N, 115° 32.604' W, 1795 m, Clark Co., NV; *Adams 11122-11124*, Hancock Summit, mile 38 on US 375, 37° 26.404' N, 115° 22.703' W, 1675 m, Lincoln Co. NV; *Adams 11125-11127*, McKinney



Figure 2. Distributions of *J. grandis*, *J. occidentalis (in part) and J. osteosperma* (in part) with Leviathan mine population noted.

Tanks Summit on US 6, 38° 07.005' N, 116° 54.103' W, 1933 m, Nye Co., NV; Adams 11134-36, 8 km s of Bridgeport, on US395, 38° 12.639' N, 119° 13.846' W, 2004 m, Mono Co., CA; Adams 11141-11143, 13 km w of Elko, on I 80, 40° 45.598' N, 115° 55.942' W, 1535 m, Elko Co., NV; Adams 11144-11146, 8 km e of Wells, on I 80, 41° 06.533' N, 114° 51.441' W, 1876 m, Elko Co., NV; Adams 11960-11962, 56 km n of Reno, NV; on US 395, 39° 54.458' N, 120° 00.322' W, 1383 m, Lassen Co., CA; Adams 11973-11977, 10 km n of CA 168 on White Mtn. Rd., 37° 20.143' N, 118° 11.346' W, 2607 m, Inyo Co., CA; Adams 11978-11982, Mahogany Flats Campground, Panamint Mtns., 36° 13.783' N, 117° 04.102' W, 2477 m, Inyo Co., CA, Adams 12323-12327, Basin, San Bernardino Mtns., 34º 16.910' N, 116º 45.306' W, 1820 m, San Bernardino Co., CA, Adams 12210-12214, ca. 1 km e of CA 18, ca. 16 km s of jct CA 18 & CA 247, n slope San Bernardino Mtns., 34º 21.213' N, 116º 50.607' W, 1393 m, San Bernardino Co. CA, Adams 12215-12219, on I15, at Bailey Rd., 35° 27.938' N, 115° 31.709' W, 1431 m, San Bernardino Co., CA. J. occidentalis, Adams 11940-11942, 12 km e of Jct. WA 14 & US 97 on WA 14, 45° 44.392' N, 120° 41.207' W, 170 m, Klickitat Co.; WA, Adams 11943-11945, 2 km s of jct. US 97 & US 197 on US 97, 38 km ne of Madras, OR; 44° 53.676' N, 120° 56.131' W, 951 m, Wasco Co., OR; Adams 11946-11948, 3 km sw of Bend, OR; on OR 372, 44° 02.390' N, 121° 20.054' W, 1132 m, Deschutes Co., OR; Adams 11949-11951, 32 km e of Bend, OR on OR 20, shrubs, 0.5 - 1m tall, 43° 53.922' N, 120° 59.187' W, 1274 m, Deschutes Co., OR; Adams 11952-11954, 14 km e of Jct. OR66 & I 5, on OR66, 42° 08.044' N, 122° 34.130' W, 701 m, Jackson Co., OR; Adams 11957-11959, on CA 299, 10 km e of McArthur, CA, 41° 05.313' N, 121° 18.921' W, 1091 m, Lassen Co., CA; Adams 11995-11998 (Kauffmann A1-A3,

B1), Yolla Bolly-Middle Eel Wilderness, 40° 06' 34" N, 122° 57' 59" W, 1815- 2000 m, Trinity Co., CA, *Adams 12342-12346*, 19 km WSE of Susanville, CA, on CA 36, 40° 22.178' N, 120° 50.211' W, 1570 m, Lassen Co., CA, *Adams 12347-12351*, on US 395, 5 km n of Madeline, 41° 05.867' N, 120° 28.456' W, 1695 m, Lassen Co., CA. Leviathan mine population: *Adams 12368-12382*, on Leviathan Mine Rd. (= Randall Terry popn.#16), 4 mi sw of US395, 38° 46.412' N; 119° 36.268' W, 6047 ft Voucher specimens are deposited in the herbarium, Baylor University (BAYLU).

Isolation of Oils - Fresh leaves (200 g) were steam distilled for 2 h using a circulatory Clevengertype apparatus (Adams, 1991). The oil samples were concentrated (ether trap removed) with nitrogen and the samples stored at -20°C until analyzed. The extracted leaves were oven dried (100°C, 48 h) for determination of oil yields.

Chemical Analyses - Oils from 10-15 trees of each taxon were analyzed and average values reported. The oils were analyzed on a HP5971 MSD mass spectrometer, scan time 1/ sec., directly coupled to a HP 5890 gas chromatograph, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column (see Adams, 2007 for operating details). Identifications were made by library searches of our volatile oil library (Adams, 2007), using the HP Chemstation library search routines, coupled with retention time data of authentic reference compounds. Quantitation was by FID on an HP 5890 gas chromatograph using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column using the HP Chemstation software. Terpenoids (as per cent total oil) were coded and compared among the species by the Gower metric (1971). Principal coordinate analysis was performed by factoring the associational matrix using the formulation of Gower (1966) and Veldman (1967). Principal components analysis (PCA) follows the formulation of Veldman (1967).

RESULTS AND DISCUSSION

Only one of the junipers in the Leviathan mine population appeared to by typical *J. grandis* (1, Table 1) and one plant appeared very similar to *J. osteosperma* (7, Table 1). The other 13 plants sampled were somewhat intermediate in morphology, but generally appeared more like *J. osteosperma*.

The oils of *J. osteosperma* are dominated by camphor (23.7%), bornyl acetate (16.6%) and sabinene (10.%, Table 2), with moderate amounts of α -pinene, borneol and terpinen-4-ol. Whereas, typical oils of *J. grandis* and *J. occidentalis* (Table 2) have little camphor (0, 2.5%) or borneol (0, 2.2%). The oil of *J. occidentalis* has large amounts of sabinene, p-cymene, citronellol and bornyl acetate (Table 2), whereas *J. grandis* oil is dominated by δ -3-carene, α -pinene and β -phellandrene (Table 2).

The oil of tree 1, field identified as *J. grandis*, is very similar to *J. grandis* (Meyers, CA, Table 2). Hybrids 9 and 11 have some intermediated components, and generally complementary components. The oils of trees 10 and 15 are similar to *J. osteosperma*, but differ in several components. They could be backcrosses or just unusual oils of *J. osteosperma*.

As a first approximation, PCO was calculated using oils from the 15 Leviathan mine plants, *J. grandis* (10, Meyers, CA, Sonora Jct., CA), *J. occidentalis* (Mc Arthur, CA, 10) and *J. osteosperma* (8 population averages, see Materials). This PCO used character weighting (in similarities) of Fs (from ANOVA between the putative parents). The ordination clearly shows that none of the Leviathan mine plants resembles *J. occidentalis* in their terpenes (Fig. 3).

Eliminating the *J. occidentalis* plants, and running a second ANOVA between *J. grandis* and *J. osteosperma*, followed by PCO analysis, focused on differences in the oils between putative parental species, *J. grandis* and *J. osteosperma*. The first two principal components removed 62 and 6% of the

variance among samples. Ordination (Fig. 4), shows the *J. grandis* individual from Leviathan mine (1, Fig. 4) to be closely allied with typical *J. grandis*. Plants 9

Table 1. Morphological observations on plants of the Leviathan mine population.

Tree #	habit	bark color	bark exfoliation	leaf glands
1	7m tree, 3 stems, J. grandis	cinnamon	shaggy strips	visible, w white exudate
2	5 m shrub, 5m x 5m	gray	shaggy strips	visible, ruptured
3	7m tree, 1 stem	brown	interlaced strips	visible, few ruptured
4	6m tree, branched at 4m	gray	strips	visible, w white exudate
5	4m tree, 3 stems, twisted	gray, orange	shaggy strips	vis. only on whip lvs., few rupt.
6	6m tree, 5 stems	gray-brown	thin strips	vis., with white exudate
7	4m shrub, J. osteosperma	gray-brown	strips	not vis., v. few ruptured
8	3m shrub	gray	shaggy strips	vis., w white exudate
9	4m shrub-tree, 10 stems	brown	shaggy strips	vis, w white exudate
10	3m tree, 1 stem, osteo BC?	gray	shaggy strips	vis, very few ruptured
11	3m shrub	gray	shaggy strips	vis., w white exudate
12	3m shrub	gray-brown	shaggy strips	vis., few w clear exudate
13	3m shrub	gray	shaggy strips	vis., few w white exudate
14	5m tree, 1 stem	gray	shaggy strips	vis., not ruptured
15	1.5m shrub x 3 m, <i>osteo</i> BC?	gray	shaggy strips	few vis., v. few ruptured
J. grand	<i>dis</i> (typical)			
	trees, 1-3 stems	cinnamon	shaggy strips	vis., few w clear/ white exud.
J. osteo	sperma (typical)			
	shrubs, trees (1- few stems)	gray-brown	thin strips	not vis., not ruptured

PCO, 49 terpenes char. wts = Fs	9	11 10 12 14 4 13 6 7 5 8 2 3 15	



Figure 3. PCO using 49 terpenes with character weights = Fs from ANOVA between *J. grandis*, *J. occidentalis*, and *J. osteosperma*.

and 11 are intermediate and presumably hybrids. Individuals 10 and 13 are closely allied with *J. osteosperma* (Fig. 4). Nine other Leviathan mine plants are clustered between individual 11 and *J. osteosperma*.

Analysis of variation among the putative hybrids revealed that, of 32 major terpenes, 6 were intermediate (between *J. grandis* and *J. osteosperma*), 8 appeared as dominant/ recessive traits having values like one of the two species and 18 terpenes were transgressive (i.e., larger or smaller than either *J. grandis* or *J. osteosperma*). Adams and Tsumura (2012), in a study of artificial hybrids within *Cryptomeria japonica*, reported that of the 17 major terpenes, 7 were intermediate and 10 were transgressive in the F_1 hybrids. Three compounds, cedrol, widdrol and cis-thujopsene, appeared to be genetically linked and inherited as a dominant/ recessive traits with some modifying genes. This group of linked, dominant/recessive compounds interfered with the ordination of hybrids between parents, such that hybrids with large amounts of cedrol, widdrol and cis-thujopsene were very difficult to separate from the Haava parent. A second study (Adams and Stoehr, 2013) of artificial hybrids of Douglas fir (*Pseudotsuga menziesii* var. *menziesii* and var. *glauca*) found that of 19 terpenes in the F_1 hybrids, 3 were intermediate, 4 dominant/ recessive and 12 transgressive. When the 12 transgressive terpenes were truncated to values between the parents, PCO ordination was improved, with the hybrids depicted as more intermediate between the parents (Adams and Stoehr, 2013).

To investigate the effects of truncation of transgressive terpenes, the 18 transgressive terpenes were truncated to values between those of *J. grandis* and *J. osteosperma*. Extraction of eigenroots showed an increase in variance in coordinate 1 (75%) and a slight decrease in coordinate 2 (5%). Ordination shows (Fig. 5) that the overall pattern is somewhat affected. The most noticeable change is in the placement of several putative hybrids as intermediate (2, 5, 7, 12, 15, Fig. 5) and ordination of several plants towards *J. osteosperma* (3, 4, 8, 10, 13, 14, Fig. 5). The ordination in fig. 5 suggests that individuals 9



Figure 4. PCO, 42 terpenes, F weighted.

Figure 5. PCO, 42 terpenes, F weighted, data truncated between *J. grandis* and *J. osteosperma* values.

11 are hybrids with plants 2,5,7,12,15 (plus 3 and 6?) being backcrosses to *J. osteosperma*, and the remaining 5 plants are *J. osteosperma*.

Additional analyses of the variation among the Leviathan plants' terpenes was made by plotting the values along with those of *J. grandis* and *J. osteosperma*. Analyses of the 6 intermediate and 8 dominant/recessive terpenes, shows that even among those scored as intermediate (α -fenchene, verbenene, β -pinene, α -cadinol, terpinen-4-ol and borneol), many Leviathan plants had zero or trace amounts, and these low values were typical of *J. osteosperma* (Fig. 6). Only terpinen-4-ol and borneol appeared to have intermediate values (Fig. 6).

For eight dominant/ recessive compounds (3-carene, 2-carene, neo-isopulegyl acetate, KI 1092, KI 1230, trans-p-menth-2-en-1-ol, neo-isopulegol and piperitone), the Leviathan plants contained zero or trace amounts (Fig. 6). For each of the 8 compounds, the zero or trace amount is typical of *J. osteosperma*. So it is easy to see why most Leviathan plants are ordinated near *J. osteosperma* (Figs. 4, 5). Of course, it may be that most of the Leviathan plants are not hybrids, but *J. osteosperma* as suggested in Figs. 4, 5.

Analyses of the 18 transgressive terpenes found they were in 7 groups: (bornyl acetate, sabina ketone, γ -thujene, cis- and trans-sabinene hydrate, camphene hydrate), (camphor, p-mentha-1,4-dien-7-ol), (sabinene, γ -terpinene), (α -terpinene), (myrcene, KI 1154, KI 1389), (terpinolene, α -phellandrene), and (α -pinene, β -phellandrene). Several of the terpenes show extreme transgressive variation (Fig. 7, bornyl acetate, camphor, α -terpinene). Several transgressive terpenes might also be considered as dominant/ recessive traits (myrcene, terpinolene, α -pinene, Fig. 7).





Figure 6. Terpenes with intermediate or dominant/ Figure 7. Terpenes with transgressive variation. recessive variation.

Recently, Adams and Stoehr (2013) investigated patterns of variation among Douglas fir hybrids, and reported that the parents and hybrids showed compounds that are zero or near zero in one parent were often zero in the hybrids. This pattern was unbalanced and many more terpenes had this pattern in the

inland parent than in the coastal parent. Thus, the similarities were biased towards the inland parent. Removing some of the redundant terpenes, led to a more intermediate ordination of the hybrids (Adams and Stoehr, 2013).

Analysis of the 24 terpenes with the largest Fs (from ANOVA between *J. grandis* and *J. osteosperma*) revealed that 7 are intermediate (Table 3) and their character weighting (as % total weight) ranged from 0.71% to 4.53%. Eight of the 24 appeared as dominant/ recessives with 3 compounds were more like *J. grandis* in Leviathan plants and 5 compounds were more like *J. osteosperma* in Leviathan plants (Table 3). Character weights ranged from 0.72% to 5.59%. Nine of the 24 terpenes were transgressive; 6 compounds were more like *J. osteosperma* in Leviathan plants (Table 3) and character weights ranged from 2.48% to 15.42%. To balance the number of characters that are like *J. grandis*

Table 3. Patterns of variation for the 24 terpenoids with the highest F ratios in ANOVA. Variation among *J. grandis* and *J. osteosperma* and Leviathan plants. x denotes the terpene occurrence pattern in *J. grandis*, Leviathan plants and/ or *J. osteosperma*. char wt = F, scaled as % total weight. char wt 1 is the original weighting based on 42 characters (Fs, scaled to % total), char wt 2 is the char weight based on 16 selected characters to balance modes between the parents (Fs, scaled to % total).

cpd .	I. grandis	Leviathan	J. osteosperma	char wt 1	char wt 2	
intermediate (7)						
α-terpinene	Х	Х	Х	2.45	3.97	
borneol	Х	Х	Х	1.15	1.86	
terpinen-4-ol	Х	Х	Х	4.16	6.73	
p-mentha-1,4-dien-7-	-ol x	Х	Х	4.53	7.33	
germacren-D-4-ol	Х	Х	Х	0.71	1.14	
epi-α-cadinol	Х	Х	Х	0.77	1.25	
α-cadinol	X	X	Х	1.08	1.74	

dominant/ recessive (8), 3 cpds more like *J. grandis* in Leviathan plants, 5 cpds more like *J. osteosperma* in Leviathan plants.

α-fenchene	Х	Х		2.26	3.66
trans-carveol	Х	Х		1.44	2.34
carvone	Х	X		1.97	3.19
camphene		Х	X	5.59	9.05
3-carene		Х	X	1.17	0
KI 1154		X	X	0.72	0
KI 1230		Х	Х	0.93	0
KI 1389		Х	Х	0.72	0

transgressive (9), 6 cpds more like J. osteosperma in Leviathan plants.

1 .			0 10	0
sahinene	X	X	2.48	()

buomene		21	21	2.10	v
γ-terpinene		Х	Х	6.28	0
cis-sabinene hydrate		Х	Х	8.19	0
camphor		Х	Х	3.34	5.42
camphene hydrate		Х	Х	12.17	0
bornyl acetate		Х	Х	3.27	5.29
α-thujene	X	Х	Х	5.63	9.11
trans-sabinene hydrate	Х	Х	Х	15.42	24.96
sabina ketone	X	Х	Х	7.98	12.92

and those like J. osteosperma, 4 terpenes were selected from the dominant/ recessive group and 5 were selected from the transgressive group along with the 7 intermediate terpenes, to make a set of 16 terpenes for PCO analysis. Note that char wt 2 values of zero (0) were not included in this group of 16 'selected' terpenes.

PCO based on 16 'selected' terpenes, with hybrids' values truncated and F weighted, produced an ordination (Fig. 8) that has only very small differences from PCO using 42 terpenes, truncated, and F weighted (Fig. 7). So, although this technique of balancing terpene characters between parents had a positive effect in Douglas fir (Adams and Stoehr, 2013), it does not seem to have an effect on the present data set. It might be noted that trans-sabinene hydrate has a very large percentage of the total weight (24.96%) in this analysis. The F value for trans-sabinene hydrate was changed to that of sabina ketone, so it had a much lower weight (i.e., equal to that of sabina ketone in the similarity), but only very, very minor differences were seen in the ordination.



Figure 7. PCO, 16 selected terpenes, wt. = Fs, and truncated terpene values for the Leviathan plants.

CONCLUSION

It appears that the Leviathan mine population samples contain one typical J. grandis, 2 hybrids, 5-10 backcrossed (to J. osteosperma) individuals and 3 plants whose oils are fairly typical of J. osteosperma. The terpene data support the haplotype data of Terry (2010). It is interesting that Terry (2010) and figure 1 (above) show 5 haplotypes in the Leviathan mine population, of which only 2 of the 5 haplotypes appear in J. osteosperma populations (none of the haplotypes appears in J. occidentalis 5 populations). It seems likely that haplotypes 6, 7, and 8 are from J. grandis germplasm.

Finally, it should be noted that the detection of hybridization using terpenoid data and multivariate methods is subject to considerable difficulty due to the dominant/recessive and transgressive traits and genetic linkage groups

giving excessive weight to some characters. The present study, using putative hybrids, mirrors the previous studies (Adams and Tsumura, 2012; Adams and Stoehr, 2013) that encountered problems with transgressive variation, linked terpenes and dominant/ recessive suites of terpenes in artificial hybrids. These problems make it difficult to accurately identify backcrossed plants.

ACKNOWLEDGEMENTS

Thanks to Billie Turner for proofing the manuscript. This research was supported with funds from Baylor University. Thanks to Tonya Yanke for lab assistance.

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Table 2. Leaf essential oil compositions for *J. osteosperma* (McKinney Tanks, NV) plus putative *J. osteosperma* backcrosses: #10, 15, putative hybrids, #9, 11, and putative *J. grandis*: #1, along with *J. grandis* (Meyers, CA) and *J. occidentalis* (Mc Arthur, CA). Compounds in boldface indicate hybridity.

KI	compound	osteo	#10	#15	#9	#11	#1	grand	occid
921	tricyclene	0.8	0.4	0.7	0.4	0.6	t	-	1.1
924	α-thujene	0.5	0.5	0.7	0.1	0.5	t	-	1.0
932	α-pinene	4.4	0.9	3.9	5.0	1.0	9.3	14.0	5.0
945	α-fenchene	-	-	t	0.8	-	1.1	1.5	t
946	camphene	1.1	0.6	1.1	0.7	0.8	-	-	1.0
953	thuja-2,4-diene	t	-	-	t	-	t	t	t
961	verbenene	-	-	0.2	1.3	-	0.4	2.9	-
969	sabinene	10.2	10.7	15.0	0.5	13.6	t	-	12.0
974	β-pinene	0.2	0.2	0.3	0.4	0.1	1.0	1.3	0.4
988	myrcene	1.7	1.5	2.7	2.2	1.8	3.6	3.1	1.3
1001	δ-2-carene	-	-	-	t	-	0.2	1.1	t
1002	α -phellandrene	0.3	0.3	0.2	0.4	0.1	2.4	1.6	0.8
1008	δ-3-carene	-	0.2	0.3	15.8	t	26.3	27.3	1.0
1014	α-terpinene	1.3	1.3	1.9	0.3	1.4	0.5	0.4	1.7
1020	p-cymene	2.4	1.4	0.7	3.1	0.8	1.3	1.4	10.7
1024	limonene	2.1	1.9	3.4	2.2	2.4	1.4	1.2	0.9
1025	ß-phellandrene	3.2	2.9	2.2	4.4	1.5	12.4	10.6	3.5
1044	(F)-B-ocimene	t	t	0.4	0.6	0.1	t	t	0.1
1054	v-terninene	2.1	2.3	3.1	1.0	2.4	0.3	0.3	3.0
1065	cis-sabinene hydrate	0.8	1.3	14	01	16	0.3	-	0.0
1078	camphenilone	t	1.0 t	11 †	-	1.0 t	-	_	-
1086	terninolene	14	0.9	14	19	0.9	42	37	13
1090	6 7-epoxymycene	0.1	-	t 1	-	t	-	-	-
1092	96, 109,43,152, C10-OH	-		t	0.7		0.3	0.9	_
1095	linalool	-	0.3	0.4	0.6	0.1	0.5	t	0.5
1098	trans-sabinene hvdrate	1.0	1.4	1.5	-	1.7	-	-	-
1102	isopentvl-isovalerate	0.2	_	t	-	t	-	_	_
1112	3-me-3-buten-methyl	0.4	t	0.6	-	0.3	-	-	-
	butanoate								
1118	cis-p-menth-2-en-1-ol	0.6	1.1	0.6	0.4	0.5	1.4	0.8	0.7
1122	α-campholenal	0.3	0.3	t	t	t	t	t	-
1136	trans-p-menth-2-en-1-ol	-	-	0.4	-	t	1.2	0.9	0.9
1141	camphor	23.7	29.5	5.5	22.9	27.8	-	-	2.5
1144	neo-isopulegol	-	-	-	-	-	0.8	0.5	-
1145	camphene hydrate	1.5	1.5	1.9	1.1	2.3	0.2	t	0.2
1154	p-menth-1,5-dien-8-ol iso.	-	-	-	-	-	1.0	0.6	-
1154	sabina ketone	0.8	1.5	0.4	1.7	0.4	-	-	0.4
1161	p-menth-1,5-dien-8-ol iso.	-	-	-	-	-	t	0.3	-
1165	borneol	6.0	1.5	2.0	1.4	0.6	-	-	2.2
1166	coahuilensol	-	-	1.6	-	-	0.4	t	0.6
1174	terpinen-4-ol	8.3	8.3	7.8	1.2	7.3	0.5	0.4	6.7
1176	m-cymen-9-ol	-	-	-	1.1	-	0.4	0.4	-
1179	p-cymen-8-ol	0.5	1.4	0.4	0.4	0.2	0.3	0.4	0.5
1186	α-terpineol	0.4	0.4	0.5	1.9	0.5	3.4	1.2	0.4
1195	myrtenol	0.2	0.2	t	t	0.3	-	-	-
1195	cis-piperitol	0.3	0.2	t	-	-	0.6	0.4	0.2
1204	verbenone	0.2	-	-	0.8	0.1	-	-	-
1207	trans-piperitol	0.3	0.3	0.3	-	0.2	1.1	0.9	0.3
1215	trans-carveol	0.6	0.4	t	-	t	-	-	-
1219	coahuilensol, me-ether	0.2	0.2	1.6	0.4	0.3	1.3	0.4	1.1
1223	citronellol	8.3	t	t	0.2	-	0.2	t	8.4
1020	trans-chrysanthenyl ac	-	-	_	0.7	_	0.5	3.9	_

1288 currone 0.3 0.3 0.1 0.2 1299 piperitone t 0.6 0.4 t 0.2 0.1 0.2 1.2 1254 metry citroneliate - - - - 0.6 0.4 - 1257 metry citroneliate - t 0.9 0.1 0.2 0.2 - 1274 nec-isopulegyl acetate 16.6 16.8 26.3 10.0 20.3 0.9 0.4 9.5 1283 actropinen-7-all 0.2 - - 0.4 0.4 0.5 1285 satrole - 0.1 0.3 1 0.2 0.4 - 1286 regraverol 0.5 0.8 0.3 - 0.1 0.3 - 1388 regraverol 0.5 0.8 0.3 - 1 0.1 0.3 0.2 1318 metry satroneli	KI	compound	osteo	#10	#15	#9	#11	#1	grand	occid
1239 carvone 0.6 0.4 t 0.2 t - 1249 piperitone t - t 1.2 t 0.3 1.2 0.2 1255 4Z-decencl - t 0.9 0.1 0.2 0.2 - 1274 neo-isopulegyl acetate - t 0.9 0.1 0.2 0.2 - 1284 bornyl acetate 16.6 16.8 28.3 10.0 20.3 0.4 0.4 1285 safrole - - - 1.0 0.5 1.9 2.5 0.4 - 1286 carvacol t t 0.3 0.4 - 1.1 0.3 - t 1.0 1.2 0.4 - 1.1 1.3 1.3 1.4 0.4 1.0 1.3 1.4 1.4 1.4 1.0 1.3 1.4 1.3 1.4 1.3 1.4 1.3 1.4	1238	cumin aldehyde	0.3	0.3	0.1	-	-	-	-	0.2
1249 piperitone t t 1.2 t 0.3 1.2 0.2 1255 42-decenci - - - - 0.6 0.4 - 1277 methy Gironellate - - 1 0.9 0.1 0.2 0.2 - 1284 heorisopulegyl acetate 16.6 16.8 26.3 10.0 20.3 0.9 0.4 9.5 1285 satrole - 0.2 - - 0.4 0.4 1318 methyl geranate - 1.1 0.5 0.4 0.4 1.0 1322 cls-piperitol acetate - 1 1.0 0.3 - 1.0 1.0.3 0.4 - 1337 p-bourboneme - - 0.3 1.0 9.0.3 - 1.141 0.5 0.2 0.3 - 1.142 0.1 1 - 0.4 0.4 0.5 0.2<	1239	carvone	0.6	0.4	t	0.2	0.1	0.2	t	-
1257 methyl citronellate - - - - 0.9 0.1 0.2 0.2 - 1274 neo-isopulegyl acetate - - t - 0.5 0.3 - 1284 bornyl acetate 16.6 16.8 28.0 10.0 20.3 0.4 9.5 1285 safrole - 0.2 - - 0.4 0.3 - 1286 carvacrol t t 0.3 0.2 0.3 t 0.2 0.4 1319 149.69.91.164, phenolic 0.4 0.6 0.7 0.5 1.9 2.5 0.4 - 1325 permetha-1,4-dien-7-ol 0.5 0.8 0.3 - 0.2 - - t 1 0.3 - 1.0 0.3 - 1.0 1.0 1.0 1.0 0.4 - 1.0 0.3 - 1.1 1.1 0.3 - 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 <td>1249</td> <td>piperitone</td> <td>t</td> <td>_</td> <td>t</td> <td>1.2</td> <td>t</td> <td>0.3</td> <td>1.2</td> <td>0.2</td>	1249	piperitone	t	_	t	1.2	t	0.3	1.2	0.2
1257 methyl citronellate - t 0.9 0.1 0.2 0.2 - 1283 a-terpinen-7-al 0.2 - 1 0.4 0.4 - - - - - - - - 1 1 1 - - - 1 1 1 - - - 1 1 1 - - - 1 1 1 - - 1 1 1	1255	4Z-decenol	-	-	-	-	-	0.6	0.4	-
1273 neo-isopulegyl acetate - t t - 0.5 0.3 - 1284 α -terpinen-7-al 0.2 - 1 1 0.5 0.4 0.4 0.4 0.4 - - - 1 1 0.2 0.4 - - - 1 1 0.3 - - 1 133 133 - - - - 1 1 0.3 - - 1 1 0.3 - 1 1333 1 - - - 1 1 1 1 <	1257	methyl citronellate	-	_	t	0.9	0.1	0.2	0.2	-
1283 α -terpinen-7-al 0.2 - 0.4 0.3 - - 0.4 0.3 - - 0.4 0.3 - - 0.4 0.4 0.5 0.4 0.6 0.7 0.5 0.4 0.4 1.0 0.4 0.4 1.0 1.03 - - - tt 1.1 0.5 0.4 0.4 1.03 0.4 - 1.03 1.03 - 1.1 1.03 - - tt 1.1 0.3 - 1.2 0.2 1.33 1.0 - 1.1 1.03 0.5 0.2 1.2 0.2 1.33 1.0 - 1.1 1.1 1.1 0.5 0.2 0.3 - 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 1.1 <td>1274</td> <td>neo-isopulegyl acetate</td> <td>-</td> <td>-</td> <td>t</td> <td>-</td> <td>-</td> <td>0.5</td> <td>0.3</td> <td>-</td>	1274	neo-isopulegyl acetate	-	-	t	-	-	0.5	0.3	-
1284 borryl acetate 16.6 16.8 26.3 10.0 20.3 0.9 0.4 9.5 1285 salrole - 0.2 - - 0.4 0.3 - 1286 carvacrol t t 0.3 0.2 0.4 0.4 1319 149,69.91.164. phenolic 0.4 0.6 0.7 0.5 1.9 2.5 0.4 - 1318 methyl geranate - - 1 1.0.5 - 0.4 0.4 1.0 1325 p-metha-1,4-dien-7-0 0.5 0.8 0.3 - 0.2 - t t 1 1.0 0.3 - 1.33 trans-piperiol acetate - - 0.3 t 0.9 0.3 - 1.03 - 1.42 0.5 0.2 3.3 1.0 - 1.12 0.5 0.2 3.3 1.0 - 1.42 0.5 0.2 0.3 1.1 <td< td=""><td>1283</td><td>α-terpinen-7-al</td><td>0.2</td><td>-</td><td>_</td><td>_</td><td>-</td><td></td><td>-</td><td>-</td></td<>	1283	α-terpinen-7-al	0.2	-	_	_	-		-	-
1285 satrole 10 0.2 10 10 0.4 0.3 1.7 1286 carvacrol t t 0.3 0.2 0.3 t 0.2 0.4 0.3 1.7 1319 143(69,91,164, phenolic 0.4 0.6 0.7 0.5 0.8 0.3 - 0.2 0.4	1284	bornyl acetate	16.6	16.8	26.3	10.0	20.3	0.9	0.4	9.5
1286 carvacrol t 1 0.3 0.2 0.3 t 0.2 0.4 1319 149,69,91,164, phenolic 0.4 0.6 0.7 0.5 1.9 2.5 0.4 - 1318 methyl geranate - - 1 0.5 0.8 0.3 - 0.2 - - 1 1322 cis-piperitol acetate - - - 1 0.1 0.3 0.4 - 1334 trans-piperitol acetate - - - 1 0.1 0.3 0.4 - 1389 111,81,151,182 - - - 1.2 0.2 3.3 1.0 - 1420 cis-thujopsene 0.7 - - - 0.1 t - 0.1 t - 0.1 1420 cis-thujopsene 0.7 - - - 0.1 t - 0.1 t - 0.	1285	safrole	-	0.2	-	-		0.4	0.3	-
1319 143.69.91, 164, phenolic 0.4 0.6 0.7 0.5 1.9 2.5 0.4 . 1318 methyl geranate - - 1.1 0.5 0.8 0.2 - 1 1325 p-mentha-1,4-diein-7-01 0.5 0.8 0.3 - 0.2 - 1 1332 trans-piperitol acetate - - - t 0.1 0.3 0.4 1337 trans-piperitol acetate - - - 0.1 0.3 0.4 1387 p1-bourbonene - - 0.3 t 0.9 0.3 - 1388 f2,43,91,180 - - - 1.2 0.2 3.3 1.0 - 1442 cis-thuigosene 0.7 - - - 0.1 t - 1443 cis-thuigosene 0.7 - - 0.3 - 0.1 1446 pinchteria, acetate 0.5 1.8 0.2 0.8 0.6 <th< td=""><td>1298</td><td>carvacrol</td><td>t</td><td>t</td><td>0.3</td><td>0.2</td><td>0.3</td><td>t</td><td>0.2</td><td>0.4</td></th<>	1298	carvacrol	t	t	0.3	0.2	0.3	t	0.2	0.4
1318 Interful geranization 0.1 0.3 1.0 0.4 1.0 1325 p-mentha-1,4-dien-7-01 0.5 0.8 0.3 - - 1 0.5 - 0.4 0.4 - 1332 cis-piperitol acetate - - t 0.1 0.3 0.4 - 1387 β-bourtonene - - - 0.1 0.3 0.4 - 1388 79,43,91,180 - - 0.3 1 0.9 0.3 - 1403 methyl eugenol - - 0.1 t - 0.1 t - 1429 cis-thuiposene 0.7 - - - 0.1 t - 0.1 1448 cis-muurola-3,5-diene - - - - 0.3 - 1471 121,05,180,208,phenol - - - 0.4 0.3 - 1474 gericubebol	1319	149 69 91 164 phenolic	04	0.6	0.7	0.5	19	25	0.4	-
1325 p-mentha-1,4-dien-7-ol 0.5 0.8 0.3 0.2 - 1 1332 cis-piperitol acetate - - 1 0.1 0.3 0.4 - 1343 trans-piperitol acetate - - - 0.1 0.3 - 1386 79,43,91,180 - - - 0.3 t 0.9 0.3 - 1403 methyl eugenol - - 0.3 t 0.9 0.3 - 1420 cis-thuippsene 0.7 - - 0.1 t - 1442 cis-thuippsene 0.7 - - - 0.1 t - 1443 cis-muurola-3,5-diene - - t t t - 0.3 - 1445 trans-muurola-3,5-diene - - - 0.8 - 0.6 - 0.2 0.8 - 0.6 1471 121,105,180,208,phenol - - - 0.2 0.2 0.3 - <td>1318</td> <td>methyl deranate</td> <td>- 0</td> <td></td> <td>11</td> <td>0.5</td> <td>1.5</td> <td>04</td> <td>0.4</td> <td>1.0</td>	1318	methyl deranate	- 0		11	0.5	1.5	04	0.4	1.0
1332 Cispiperiol acetate - - t 0.1 0.3 0.4 - 1343 trans-piperiol acetate - - - 1 0.1 0.3 - 1387 β-bourbonene - - - - 1 0.5 0.2 1388 79,43,91,180 - - - 0.3 1 0.9 0.3 - 1403 methyleugenol - - - 0.1 t - 0.1 t - 0.1 t - 0.1 t - 0.3 - 0.1 t - - 0.1 t - - 0.1 t - 0.1 t - 0.1 142 cis-tuiposene 0.7 - - 0.1 t - 0.1 143 t t 0.1 0.1 0.3 0.2 0.8 - 0.1 143 t t 0.3	1325	n-mentha-1 4-dien-7-ol	0.5	0.8	03		0.2		-	1.0 t
1343 trans-piperiol acetate - - - - - - 1 0.1 0.3 - 1387 β-bourbonene - - - - - t 10 0.3 - 1388 79.43.91.180 - - 0.3 t 0.9 0.3 - 1429 cis-rhujopsene 0.7 - - - 0.1 t - 0.9 1448 cis-muurola-3.5-diene - - t t t - 0.1 t - 0.1 1 - 1445 trans-muurola-3.5-diene - - - - 0.1 1 - 0.1 1 1 1 1 1 - 0.1 1 1 1 1 1 1 0.1 1 - 0.1 1 1 1 1 1 1 1 1 1 1 1	1323	cis-ninerital acetate		0.0		+	0.2	03	04	
1387 β-bourbonene - - - - 0.1 0.5 0.2 1388 79,43,91,180 - - - 0.3 t 0.9 0.3 - 1403 methyl eugenol - - - 1.2 0.2 3.3 1.0 - 1420 methyl eugenol - - - - - 0.1 t - 1421 cis-muurola-3,5-diene 0.7 - - - - 0.1 t - 1445 trans-muurola-4,5-diene - - - - 0.1 t - 0.1 t - 0.1 t - - 0.1 t - 0.1 t<	13/3	trans-piperitol acetate					0.1	0.0	03	
1307production in1111110.21388 $79.43.91, 180$ 0.3t0.90.3-1429ist-hujopsene0.70.11-1429cis-hujopsene0.70.90.11448cis-muurola-3,5-diene0.11465cis-muurola-4,5-diene0.11468pinchotene acetate0.5t0.80.2-0.8-0.61471121.105,180,208,phenol0.31475trans-cadina-1(6),40.31478y-muurolene0.40.3-1474y-muurolene0.40.41474y-muurolene1-0.20.20.31.11.11500 α -muurola-4(14),5t10.41474y-muurolene1-0.21.0-0.20.31.11500 α -muurolene1-0.21.0-0.20.31.11518epi-cubebolttt0.40.41522δ-cadinene	1297		-	-	-	-	-	+	0.5	0.2
1389 11.81,151,182 - - 1.2 0.2 3.3 1.0 - 1403 methyl eugenol - - - - 0.1 t - 0.9 3.3 1.0 - 1403 methyl eugenol - - - - 0.1 t - 0.9 1442 cis-muurola-3,5-diene - - 1 - - 0.1 t - 0.1 1468 picmohene acetate 0.5 t 0.8 0.2 0.8 - 0.6 1471 121.105.180,208,phenol - - - - 0.2 0.2 0.3 - 1478 γ-muurolene - - - - 0.2 0.2 0.3 1484 germacrene D - - - - 1 0.4 1500 α-muurolene t - 0.2 0.3 0.2 0.3 1.1 <td>1307</td> <td></td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>ر د</td> <td>0.5</td> <td>0.2</td>	1307		-	-	-	-	-	ر د	0.5	0.2
1363111,81,181,182120.23.31.0-1403methyl eugenol0.1t-1429cis-thujopsene0.70.1t1441cis-muurola-3,5-dienett-0.91445trans-muurola-3,5-diene0.1t1465cis-muurola-4,5-diene0.111471121,105,180,208,phenol0.3-1475trans-cadina-1(6),40.20.3-1478y-muurolene0.4-0.4diene0.4-1484germacrene D0.4-1493epi-cubebol0.4-1503 α -muurolenet0.20.30.30.20.61.33.71518epi-cubebol1522ô-cadinene0.20.30.60.40.30.71.14.11534c-calacorene1548elemici <t< td=""><td>1300</td><td><u>79</u>,43,91,180</td><td>-</td><td>-</td><td>-</td><td>0.3</td><td></td><td>0.9</td><td>0.3</td><td>-</td></t<>	1300	<u>79</u> ,43,91,180	-	-	-	0.3		0.9	0.3	-
1429 intertly legend - 1 1 1 1 - - 1 1 1 - - 1 1 1 - - 0.3 - 0.1 1448 is and	1389	<u>111,81,151,182</u>	-	-	-	1.2	0.2	3.3	1.0	-
1428 cis-nuurola-3,5-diene - - - - - 0.1 1448 cis-nuurola-3,5-diene - - - - - 0.1 1451 trans-muurola-3,5-diene - - - - - 0.1 1468 pinchotene acetate 0.5 t 0.8 0.2 0.8 - 0.6 1471 121,105,180,208,phenol - - - - 0.3 - 1475 trans-cadina-1(6),4- - - - - 0.2 0.3 - 1478 y-muurolene - - - - 0.2 0.2 0.3 1484 germacrene D - - - - - 0.2 0.2 0.3 1493 tepi-cubebol - - - - t 1 0.4 0.4 1500 α -muurolene t 0.2 0.3 0.6 0.4 0.3 0.7 1.1 4.1 1503 epi-cubebol	1403		-	-	-	-	-	0.1	t	-
1448 cis-muurola-3,5-diene - - t - t - - - - - - 0.1 1465 cis-muurola-3,5-diene - - - - 0.1 0.1 1466 pinchotene acetate 0.5 t 0.8 0.2 - 0.8 - 0.6 1471 121,105,180,208,phenol - - - - 0.3 - 1475 trans-cadina-1(6),4- - - - - - 0.2 0.2 0.3 1478 y-muurolene - - - - - 0.2 0.2 0.3 1484 germacrene D - - - - - 0.4 - 0.4 diene - - - - - 1 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 - 0.4 0.4 - <t< td=""><td>1429</td><td>cis-thujopsene</td><td>0.7</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>0.9</td></t<>	1429	cis-thujopsene	0.7	-	-	-	-	-	-	0.9
1451 trans-muurola-3,5-diene - - - - - - 0.1 1465 cis-muurola-4,5-diene - - - - - 0.3 - 1471 121,105,180,208,phenol - - - - - 0.3 - 1475 trans-cadina-1(6),4- - - - - - 0.2 0.2 0.3 1478 γ -muurolene - - - - - 0.2 0.2 0.3 1484 germacrene D - - - - 0.2 0.2 0.3 1493 trans-murola-4(14),5- - - - - - 0.2 0.2 0.3 1493 trans-murola-4(14),5- - - - t t 0.4 0.4 1493 trans-murola-4(14),5- - - - t t 0.4 0.4 1513 γ -cadinene t 0.2 0.3 0.3 0.7 1.1 4.1 <	1448	cis-muurola-3,5-diene	-	-	-	t	-	t	t	-
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	1451	trans-muurola-3,5-diene	-	-	-	-	-	-	-	0.1
1468 pinchotene acetate 0.5 t 0.8 0.2 - 0.8 - 0.6 1471 121,105,180,208,phenol - - - - - 0.3 - 1475 trans-cadina-1(6),4- - - - - - 0.2 0.3 1478 y-murolene - - - - - 0.2 0.2 0.3 1484 germacrene D - - - - - 0.2 0.2 0.3 1493 trans-murola-4(14),5- - - - - - 0.2 0.3 1.1 1500 α-muurolene t 0.2 0.3 0.3 0.2 0.6 1.3 3.7 1518 epi-cubebol - - - t t 0.4 0.4 0.4 1527 α-cadinene 0.2 0.3 0.6 0.4 0.3 0.7 1.1 4.1 1537 α-cadiacorene - - - t 1	1465	cis-muurola-4,5-diene	-	-	-	-	-	-	-	0.1
1471121,105,180,208,phenol0.3-1475trans-cadina-1(6),40.31478 γ -muurolene0.81484germacrene D0.20.20.31493trans-murrola-4(14),50.4diene0.40.41503 α -muurolenet-0.21.0-0.20.31493epi-cubeboltt0.41513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522δ-cadinene0.20.30.60.40.30.71.14.11537 α -cadacorene0.31548elemol0.90.60.10.50.70.21555elemicin0.31548germacrene-D-4-olt0.30.60.40.30.70.70.61552caryophyllene oxidettttttt10.21607β-oplopenonett<	1468	pinchotene acetate	0.5	t	0.8	0.2	-	0.8	-	0.6
1475trans-cadina-1(6),4- diene0.31478 γ -muurolene0.20.20.31484germacrene D0.20.20.31493trans-murrola-4(14),5- diene0.20.20.31493epi-cubebol0.41500 α -muurolenet0.20.30.30.20.61.33.71518epi-cubeboltt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadiacorenett0.30.61555elemicin1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidettttttt1.21607 β -oplopenonettttttt1.20.40.41522 δ -cadinene0.21.5-1555elemicinttttttt	1471	<u>121,105,180,208,phenol</u>	-	-	-	-	-	-	0.3	-
diene0.81478γ-muurolene0.20.31484germacrene D0.20.31493trans-murola-4(14),50.41500 α -muurolenet-0.21.0-0.20.31513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubeboltt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.40.41548elemol0.90.60.10.50.70.21555elemicintt0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61586gleenol1586gleenol1687g-polopenonetttttt1.00.21687gleenol1586gleenoltt11	1475	trans-cadina-1(6),4-	-	-	-	-	-	-	-	0.3
1478 γ -muurolenet-0.81484germacrene D0.20.20.31493trans-murola-4(14),50.40.41500 α -muurolenet0.41500 α -muurolenet-0.21.0-0.20.31.11513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.41548elemol0.90.60.10.50.70.21555elemicintttt-1574germacrene-D-4-olt0.60.40.30.70.70.61582caryophyllene oxidetttttt1586gleenol16181,10-di-epi-cubenol </td <td></td> <td>diene</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		diene								
1484germacrene D0.20.20.31493trans-murrola-4(14),50.41493epi-cubebol0.41500 α -muurolenet-0.21.0-0.20.31513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.40.41544 α -calacorene0.31548elemol0.90.60.10.50.70.21555elemicinttt-0.30.61582caryophyllene oxidetttttt-t-1586gleenol1687β-oplopenonettttttt0.20.40.416881.0-di-epi-cubenol1586gleenol <td>1478</td> <td>γ-muurolene</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>t</td> <td>-</td> <td>0.8</td>	1478	γ-muurolene	-	-	-	-	-	t	-	0.8
1493 dienetrans-murrola-4(14),5- diene0.41493 1500epi-cubebol0.41500 1510 α -muurolenet0.20.30.30.20.61.33.71513 1518 2 γ -cadinenet0.20.30.30.20.61.33.71518 1522 2 \diamond -cadinene0.20.30.60.40.30.71.14.11527 1527 2 ecadinenett0.40.41548 1548 2 elemol0.20.30.60.40.30.71.14.11547 1555 2 elemicin1552 1554 2 elemol0.90.60.10.50.70.21.51574 1582 2 earyophyllene oxidettttttt0.21.5-1585 1682 2 caryophyllene oxidetttttttt1.61.81.61.81.6	1484	germacrene D	-	-	-	-	-	0.2	0.2	0.3
dienedienedienediene1493epi-cubebol0.21.01500 α -muurolenet-0.21.0-0.20.31.11513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubeboltttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenettt0.41548elemol0.90.60.10.50.70.21555elemicintt-0.21.5-1582caryophyllene oxidetttttt-t-t1586gleenol0.30.61607 β -oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-ttttt1.016181,10-di-epi-cubenol16181,10-di-epi-cubenoltt1.11.61638epi- α -cadinol0.2t <td>1493</td> <td>trans-murrola-4(14),5-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>0.4</td>	1493	trans-murrola-4(14),5-	-	-	-	-	-	-	-	0.4
1493epi-cubebolt-0.41500 α -muurolenet-0.21.0-0.20.31.11513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.40.41544 α -calacorenet0.30.71.14.11548elemol0.90.60.10.50.70.21555elemicintt-0.21.51574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt1586gleenol0.31607β-oplopenonettttttt10.216181,10-di-epi-cubenol <t< td=""><td></td><td>diene</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>		diene								
1500 α -muurolenet-0.21.0-0.20.31.11513γ-cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadiacorenett0.41548elemol0.90.60.10.50.70.21555elemicintt-0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt-1586gleenol0.30.61607β-oplopenonetttt0.5t0.20.40.41628humulene epoxide IIt-t16181,10-di-epi-cubenoltt1.60.21.616271-epi-cubenoltt1.61.81630γ-eudesmol0.2t1638epi-α-cadinolt<	1493	epi-cubebol	-	-	-	-	-	t	-	0.4
1513 γ -cadinenet0.20.30.30.20.61.33.71518epi-cubebolttt0.40.41522 δ -cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.41548elemol0.90.60.10.50.70.21548elemol0.90.60.10.50.70.21555elemicintt-0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt-1586gleenol0.30.70.70.61607 β -oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-tttt1.616181,10-di-epi-cubenoltt1.616271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30	1500	α-muurolene	t	-	0.2	1.0	-	0.2	0.3	1.1
1518epi-cubeboltttt0.40.41522δ-cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.41544 α -calacorene110.41548elemol0.90.60.10.50.70.21555elemicintt-0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidettttt0.31607β-oplopenonettt0.5t0.20.40.41608humulene epoxide IIt16181,10-di-epi-cubenolttt0.20.416271-epi-cubenol16181,10-di-epi-cubenol16271-epi-cubenol1638epi- α -cadinol0.2t0.30.30.20.60.71.11.616	1513	γ-cadinene	t	0.2	0.3	0.3	0.2	0.6	1.3	3.7
1522δ-cadinene0.20.30.60.40.30.71.14.11537 α -cadinenett0.41544 α -calacorene0.31548elemol0.90.60.10.50.70.21555elemicint0.21.5-1555elemicintt-0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidettttt0.31607β-oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-tttt0.20.40.41608humulene epoxide IIt-tttt0.20.40.41638gei-α-cadinolttt1.61638epi-α-cadinolt0.20.30.30.20.60.71.21644 α -muurolol-ttttttt0.71649β-eudesmol0.2t-ttttt1.21652 α -eudesm	1518	epi-cubebol	-	-	-	t	t	t	0.4	0.4
1537α-cadinenett0.41544α-calacorene0.31548elemol0.90.60.10.50.70.21555elemicint0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt1586gleenol0.31607β-oplopenonetttt0.5t0.20.41608humulene epoxide IIt-tttt0.216181,10-di-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.30.30.20.60.71.21644 α -muurolol-tttttt0.4-1652 α -eudesmol0.20.3-0.51652 α -eudesmol0.20.31.00.60.71.21.61.8 <t< td=""><td>1522</td><td>δ-cadinene</td><td>0.2</td><td>0.3</td><td>0.6</td><td>0.4</td><td>0.3</td><td>0.7</td><td>1.1</td><td>4.1</td></t<>	1522	δ-cadinene	0.2	0.3	0.6	0.4	0.3	0.7	1.1	4.1
1544 α-calacorene0.31548elemol0.90.60.10.50.70.21555elemicint0.30.60.40.30.70.70.61574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidettttt0.31607β-oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt1.60.20.21.616271-epi-cubenoltt1.61630γ-eudesmol0.2t1638epi-α-cadinolt0.20.30.30.20.60.71.11638epi-α-muurolol-tttttt0.71.21644 α -muurolol-ttttttt0.71.21652 α -eudesmol0.20.31.00.60.71.21.61.81688shyobunolttttt <td< td=""><td>1537</td><td>α-cadinene</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>t</td><td>t</td><td>0.4</td></td<>	1537	α-cadinene	-	-	-	-	-	t	t	0.4
1548elemol0.90.60.10.50.70.2-1555elemicint0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt-1586gleenol0.30.70.70.61607β-oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt0.20.40.416271-epi-cubenoltt1.61.61630γ-eudesmol0.2t1638epi-α-cadinolt0.20.30.30.20.60.71.11638epi-α-muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttttt0.71652 α -eudesmol0.20.31.00.60.71.21.61.81688shyobunolttttt-1739	1544	α-calacorene	-	-	-	-	-	-	-	0.3
1555elemicint-0.21.5-1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidettttttt1586gleenol0.31607β-oplopenonetttt0.5t0.20.41608humulene epoxide IIt-t0.31607β-oplopenonetttt0.5t0.20.41608humulene epoxide IIt-t-t1t0.216181,10-di-epi-cubenoltt0.21.616271-epi-cubenoltt10.21638epi- α -cadinol0.2t1638epi- α -cadinolt0.20.40.40.20.60.71.11638epi- α -cadinol0.2t-tttt0.71644 α -muurolol-tttttt0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.7	1548	elemol	0.9	0.6	0.1	0.5	0.7	0.2	-	-
1574germacrene-D-4-olt0.30.60.40.30.70.70.61582caryophyllene oxidetttttt11586gleenol0.31607β-oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt0.20.40.41630γ-eudesmol0.2ttt1.61630γ-eudesmol0.2t1638epi-α-cadinolt0.20.30.30.20.60.71.11638epi-α-muurololt0.20.40.40.20.60.71.21644α-muurolol-ttttttt0.71649β-eudesmol0.20.3-0.51652α-cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.20.2-1739oplopanonetttt0.2tttt11987	1555	elemicin	-	-	t	-	_	0.2	1.5	_
1582caryophyllene oxidetttttttt1582caryophyllene oxidettttttt-1586gleenol0.31607 β -oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-tt16181,10-di-epi-cubenoltt0.20.40.416271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -cadinolt0.20.40.40.20.60.71.21644 α -muurololtt0.20.30.30.20.60.71.21644 α -muurolol-ttttttt0.71649 β -eudesmol0.21.31.00.60.71.21.61.81652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-ttt<	1574	germacrene-D-4-ol	t	0.3	0.6	0.4	0.3	0.7	0.7	0.6
1586gleenol0.31607 β -oplopenonettttt0.5t0.20.40.41608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt0.20.40.416271-epi-cubenoltt0.216271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-tttttt0.71649 β -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-tttt-1739oplopanonetttt0.2tttt1-1987manoyl oxidettttt3.2	1582	carvophyllene oxide	t	t	t	t	-	-	t	-
1600groundtttt0.5t0.20.40.41607 β -oplopenonetttt0.5t0.20.40.41608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt0.216271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -cadinolt0.20.40.40.20.60.71.21644 α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttt0.71649 β -eudesmol0.20.3-0.51652 α -eudesmol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.21739oplopanonettt0.2tttt-1987manoyl oxidetttt3.2	1586	aleenol	-	-	-	-	_	-	-	0.3
1608humulene epoxide IItttttttttt1608humulene epoxide IIt-t-t16181,10-di-epi-cubenoltt0.216271-epi-cubenoltt0.21630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttt0.71.21649 β -eudesmol0.21-t0.1-0.4-1652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81688shyobunol0.2-ttt-1739oplopanonetttt0.2tttt3.21987manoyl oxidettttt3.2	1607	B-onlonenone	t	t	t	0.5	t	0.2	0.4	0.4
1000Intiluence epokterin1111111116181,10-di-epi-cubenoltt0.216271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttt0.71649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.21739oplopanonetttt0.2tttt-1987manoyl oxidetttt3.2	1608	humulene enovide II	t	-	+ +	-	+	-	-	
16101, 10 dr cpr cabenolttt0.216271-epi-cubenoltt1.61630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-tttttt0.71649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.20.2-1739oplopanonetttt0.2tttt1987manoyl oxidettt-tt3.2	1618	1 10-di-eni-cubenol		_			ι <u>ι</u>	+	t	0.2
10271-epi-cuberion1111.01630 γ -eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttttt0.71649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81652 α -eudesmol0.20.31.00.60.71.21.61.81658shyobunol0.2-ttt-1739oplopanonetttt0.2tttt3.21987manoyl oxidetttttt3.2 <td>1627</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>+</td> <td>ι +</td> <td>ι +</td> <td>1.6</td>	1627						+	ι +	ι +	1.6
1030γ-eudesmol0.2t1638epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-tttttt0.71649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81652 α -cadinol0.20.31.00.60.71.21.61.81658shyobunol0.2-tttt-1739oplopanonetttt0.2tttt3.21987manoyl oxidettt-tt3.2	1620			+	-			L L	L	1.0
1030epi- α -cadinolt0.20.30.30.20.60.71.11638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-tttttt0.71.21649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-tt0.20.2-1739oplopanonetttt0.2tttt-1987manoyl oxidettt3.2	1030		U.2		-	-	-	-	-	-
1638epi- α -muurololt0.20.40.40.20.60.71.21644 α -muurolol-ttttttt0.71649 β -eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-tt0.20.2-1739oplopanonetttt0.2tttt3.21987manoyl oxidettt-t3.2	1038	epi-α-cadinol	L L	0.2	0.3	0.3	0.2	U.b	0.7	1.1
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1638	epi-α-muurolol	t	0.2	0.4	0.4	0.2	0.6	0.7	1.2
1649β-eudesmol0.2t-t0.1-0.4-1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.20.2-1739oplopanonettt0.2tttt1987manoyl oxidett-t3.2	1644	α-muurolol	-	t	t	t	t	t	t	0.7
1652 α -eudesmol0.20.3-0.51652 α -cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.20.2-1739oplopanonettt0.2tttt1987manoyl oxidettt-tt	1649	β-eudesmol	0.2	t	-	t	0.1	-	0.4	-
1652α-cadinol0.20.31.00.60.71.21.61.81688shyobunol0.2-t0.20.2-1739oplopanonettt0.2ttt-1987manoyl oxidett-t3.2	1652	α-eudesmol	0.2	0.3	-	0.5	-	-	-	-
1688 shyobunol - - 0.2 - t 0.2 0.2 - 1739 oplopanone t t t 0.2 t t t - 1987 manoyl oxide - - t t - t 3.2	1652	α-cadinol	0.2	0.3	1.0	0.6	0.7	1.2	1.6	1.8
1739 oplopanone t t t t 0.2 t t t - 1987 manoyl oxide - - t t - t t 3.2	1688	shyobunol	-	-	0.2	-	t	0.2	0.2	-
1987 manoyloxide t t - t t 3.2	1739	oplopanone	t	t	t	0.2	t	t	t	-
	1987	manoyl oxide	-	-	t	t	-	t	t	3.2

KI	compound	osteo	#10	#15	#9	#11	#1	grand	occid
2009	epi-13-manoyl oxide	-	-	-	-	-	-	-	t
2056	manool	-	-	t	-	-	t	t	-
2055	abietatriene	-	-	t	t	-	t	t	-
2298	4-epi-abietal	-	-	t	t	-	t	t	-
2312	abieta-7,13-dieen-3-one	0.1	-	-	-	t	-	-	-

KI = linear Kovats Index on DB-5 column. *Tentatively identified. Compositional values less than 0.1% are denoted as traces (t). Unidentified components less than 0.5% are not reported.